

First Zoea of *Heptacarpus rectirostris* (Decapoda, Caridea, Hippolytidae) Hatched in the Laboratory, with Notes on the Larval Characters of *Heptacarpus*

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ABSTRACT

The first zoeal stage of *Heptacarpus rectirostris* (Stimpson, 1860) is re-described and illustrated in detail from laboratory-hatched material. The first zoea of *H. rectirostris* is more closely related to that of *H. futilirostris* than to *H. camtschaticus*, *H. pandaloides*, and *H. geniculatus* by having the pterygostomial spine and two anteroventral denticles on the carapace. The former two species, however, can be readily distinguished by the presence (*H. futilirostris*) or absence (*H. rectirostris*) of the posterolateral spine on the abdominal somites 4-5. A provisional key to the first zoeas of *Heptacarpus* for which larval studies are known from Korea and adjacent waters is provided. A list of larval descriptions within the Hippolytidae from Korea and adjacent waters is also included.

Key words: first zoea, *Heptacarpus rectirostris*, Hippolytidae, Caridea, Key

INTRODUCTION

Knowledge of hippolytid larvae world-wide is currently very limited. This situation makes it difficult for us to identify hippolytid larvae from plankton samples so we cannot assign them to its

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Table 1. List of hippolytid species and larval stages described from Korea and adjacent waters. ① = description from plankton samples; ② = abbreviated development; Z, P, and Y = zoeal, postlarval, and young stages, respectively

Species	Stages	Region	References
<i>Alope spinifrons</i>	Z1-5	New Zealand	Packer, 1985
<i>Eualus barbatus</i>	Z1	Bering Sea, Russia	Ivanov, 1971
<i>Eualus fabricci</i>	Z1-2	Kachemak Bay, Alaska	Haynes, 1981
<i>Eualus leptognathus</i>	Z1-9,P	Seto Inland Sea, Japan	Yamashita and Hayashi, 1984
<i>Eualus macilentus</i>	Z1	Bering Sea, Russia	Ivanov, 1971
<i>Eualus sinensis</i> as <i>Eualus gracilirostris</i>	Z1-9,P	Sagami Bay, Japan	Kurata, 1968a
<i>Eualus sinensis</i>	Z1	Sangju, Korea	Yang <i>et al.</i> , 2001
<i>Eualus suckleyi</i>	Z1-2	Kachemak Bay, Alaska	Haynes, 1981
<i>Heptacarpus camtschaticus</i>	Z1	Kachemak Bay, Alaska	Haynes, 1981
<i>Heptacarpus futilirostris</i>	Z1-9,P	Sagami Bay, Japan	Kurata, 1968b
<i>Heptacarpus geniculatus</i> as <i>Spirontocaris geniculata</i>	Z1	Japan	Yokoya, 1957
<i>Heptacarpus geniculatus</i>	Z1-9,P	Sagami Bay, Japan	Kurata, 1968c
<i>Heptacarpus geniculatus</i>	Z1-9,P,Y	Seto Inland Sea, Japan	Yamashita and Hayashi, 1980
<i>Heptacarpus pandaloides</i> as <i>Spirontocaris pandaloides</i>	Z1	Japan	Yokoya, 1957
<i>Heptacarpus pandaloides</i>	Z1-7,P,Y	Seto Inland Sea, Japan	Yamashita and Hayashi, 1980
<i>Heptacarpus rectirostris</i> as <i>Spirontocaris rectirostris</i>	Z1	Japan	Yokoya, 1957
<i>Heptacarpus rectirostris</i>	Z1-9,P	Seto Inland Sea, Japan	Yamashita and Hayashi, 1979
<i>Heptacarpus rectirostris</i>	Z1	Changseon, Korea	present study
<i>Hippolyte acuta</i>	Z1	Okinawa, Japan	Yokoya, 1957
<i>Hippolyte bifidirostris</i>	Z1-3	New Zealand	Packer, 1985
<i>Hippolyte multicolorata</i>	Z1-8	New Zealand	Packer, 1985
<i>Latreutes laminirostris</i>	Z1-9,P	Hadong, Korea	Kim and Hong, 1999
<i>Latreutes mucronatus</i>	Z4①	Great Barrier Reef, Australia	Gurney, 1937
<i>Lebbeus groenlandicus</i>	Z1	Bering Sea, Russia	Ivanov, 1971
<i>Lebbeus groenlandicus</i>	Z1-2,P②	Kachemak Bay, Alaska	Haynes, 1978
<i>Lebbeus polaris</i>	Z1-2②	Kachemak Bay, Alaska	Haynes, 1981
<i>Nauticaris marionis</i>	Z1	New Zealand	Packer, 1985
<i>Spirontocaris arcuata</i>	Z1	Kachemak Bay, Alaska	Haynes, 1981
<i>Spirontocaris murdochi</i>	Z1-3	Kachemak Bay, Alaska	Haynes, 1984
<i>Spirontocaris ochotensis</i>	Z1	Kachemak Bay, Alaska	Haynes, 1981
<i>Spirontocaris spinus</i> as <i>Spirontocaris spina intermedia</i>	Z1-4①,P①	Sea of Okhotsk, Russia	Makarov, 1967
<i>Spirontocaris spinus</i> as <i>Spirontocaris spina intermedia</i>	Z1	Bering Sea, Russia	Ivanov, 1971
<i>Tozeuma novaezealandiae</i>	Z1	New Zealand	Packer, 1985

proper genus. For this problem, detailed descriptions of the first zoeas of the Hippolytidae are essential for accurate larval identification.

Forty-one hippolytid genera at least have been reported from world-wide (Holthuis, 1993), of which nine genera represented by 25 species (8 species from Korea and Japanese waters, 11 from Alaska and Russian waters, and 6 from Australia and New Zealand waters) are known for partial or complete larval developments from Korea and adjacent waters (Table 1). Within *Heptacarpus*, the larvae of eight species have been studied world-wide, five of which are known from Korea and adjacent waters. The first zoeal stages of the remaining three species described by Needler (1933) have been reported from Canadian waters: *Heptacarpus brevirostris* (Dana, 1852) as *Spirontocaris brevirostris* Walker, 1898, *Heptacarpus paludicola* Holmes, 1900 as *Spirontocaris paludicola* Rathbun, 1904, and *Heptacarpus tridens* (Rathbun, 1902) as *Spirontocaris tridens* Rathbun, 1902. Needler (1933)'s description, however, is too brief and inadequate from a modern point of view. Pike and Williamson (1961), Makarov (1967), and Haynes (1985) established larval characters for the members of *Heptacarpus*. However, the characters provided by previous authors are somewhat erroneous because these were mainly based on the description of Needler (1933). Therefore, it should be amended by the larval information of *Heptacarpus* known thereafter. The descriptions of the first zoeal stage of *Heptacarpus rectirostris* (Stimpson, 1860) provided by Yokoya (1957) and Yamashita and Hayashi (1979) are also not informative for morphological comparison with those of the congeners of *Heptacarpus*.

The present study, therefore, provides detailed description of the first zoeal stage of *H. rectirostris*, compares it with those of other congeners of *Heptacarpus*, and constructs a key to the first zoeas of *Heptacarpus* known from Korea and adjacent waters.

MATERIALS AND METHODS

On March 17, 2001, ovigerous females of *Heptacarpus rectirostris* were collected from Chanseon, Namhae, southern part of Korea. The first zoea hatched in the laboratory was fixed and preserved in 7% neutral Formalin. Dissected appendages were examined using a Leitz Laborlux s microscope. Drawings were based on 10 specimens and made with the help of a camera lucida. Illustrations were made with Illustrator™ 8.0 (Adobe System Inc.). Setal armature on appendage was described from proximal to distal segmentation. Body length (BL) and carapace length (CL) were measured from the posterorbital margin to the posterior margin of telson and to the posteromedian end of carapace, respectively. The chromatophore patterns were examined by living larvae.

RESULTS

First Zoea (Figs. 1, 2)

Size. BL. mean 1.62 mm; CL. mean 0.39 mm.

Carapace (Figs. 1A, B). Rostrum minute, pointed, simple, not extending to beyond eyes. Anterior

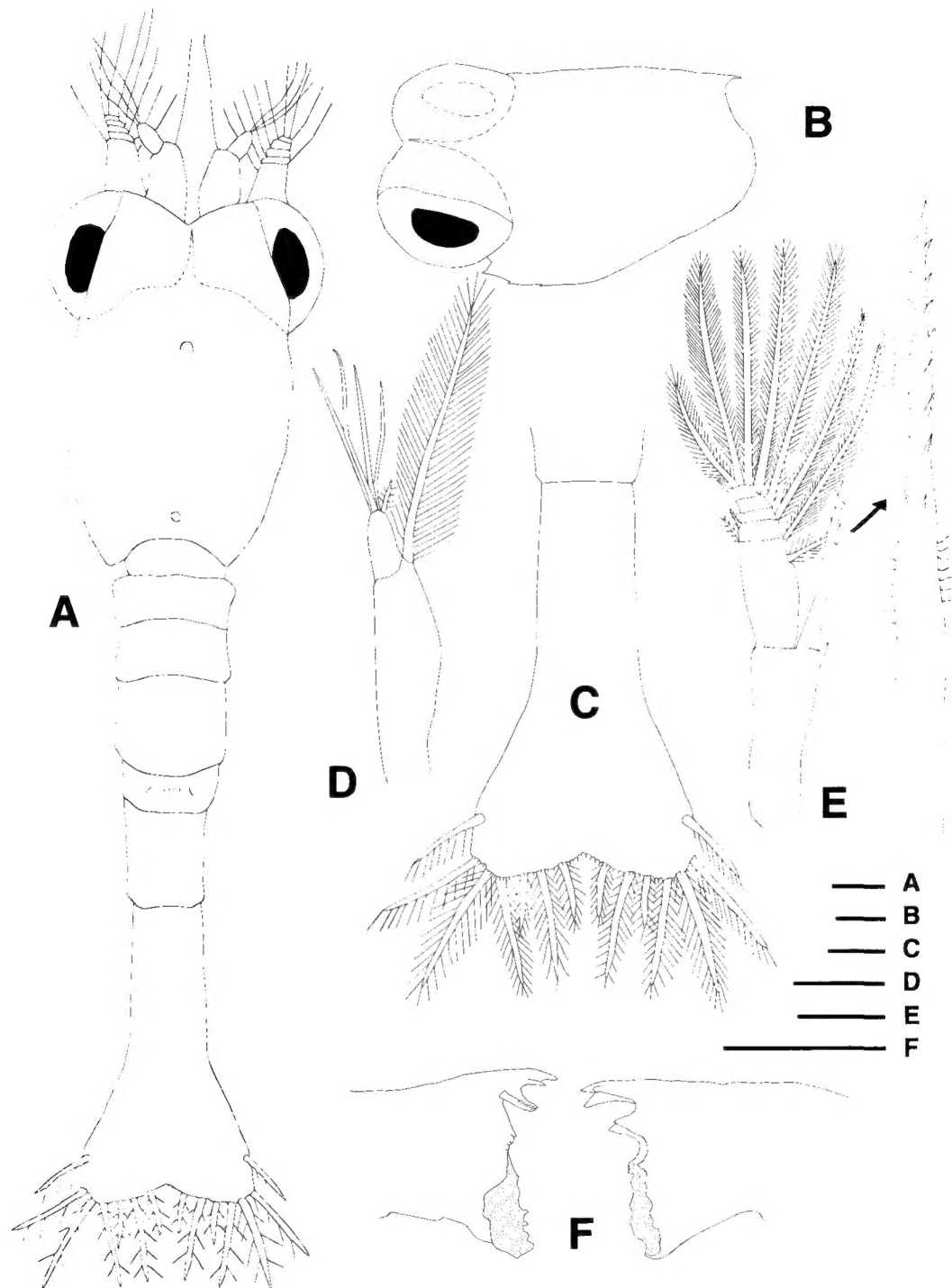


Fig. 1. First zoea of *Heptacarpus rectirostris*. A, dorsal view; B, dorsolateral view of carapace; C, telson; D, antennule; E, antenna; F, mandibles. Scale bars equal 0.1 mm.

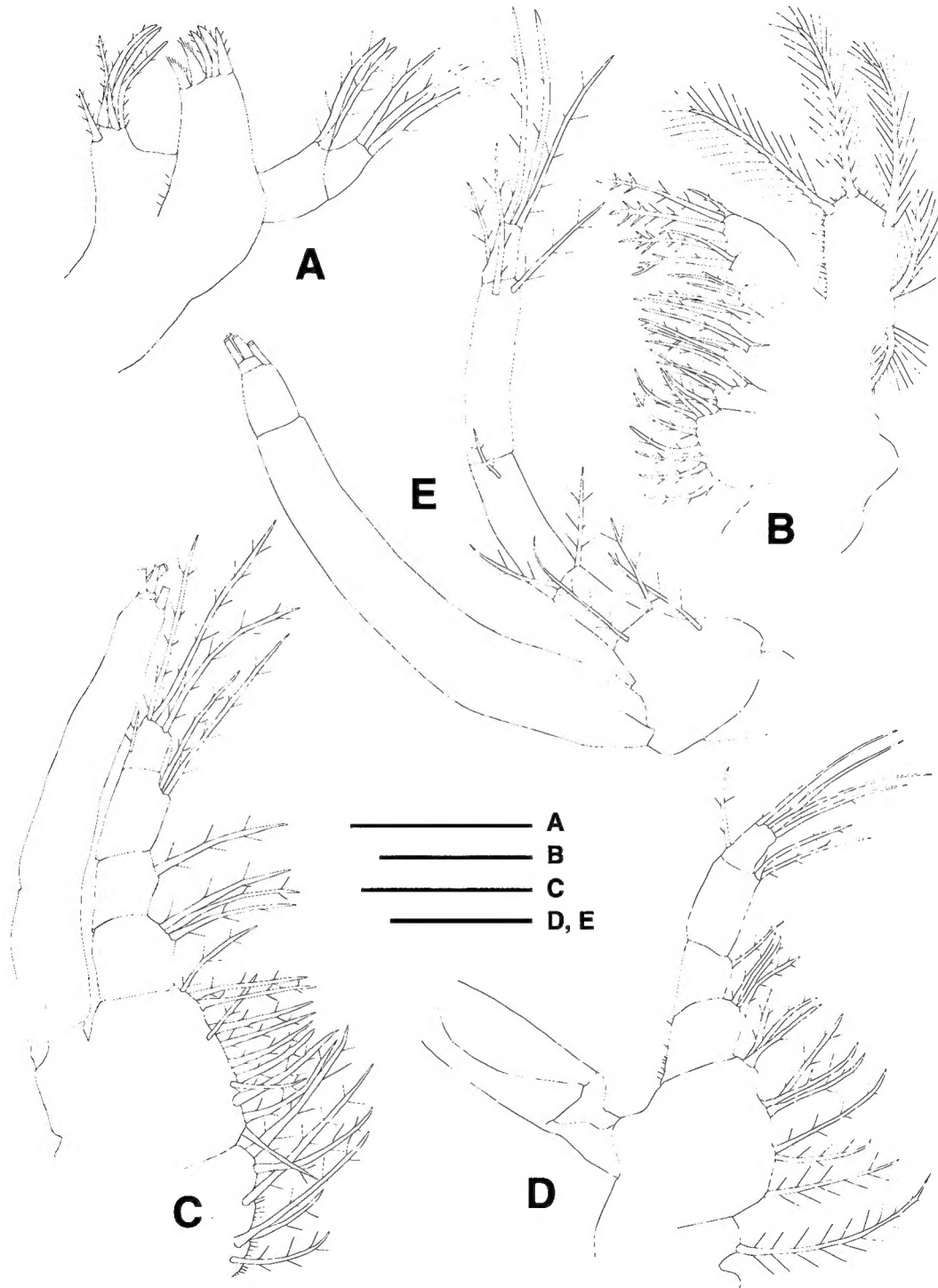


Fig. 2. First zoea of *Heptacarpus rectirostris*. A, maxillule; B, maxilla; C, first maxilliped; D, second maxilliped, exopod truncated; E, third maxilliped. Scale bars equal 0.1 mm.

dorsomedian and posterior dorsomedian papillae present. Anteroventral margin with 2 denticles behind pterygostomial spine. Eyes sessile.

Abdomen (Fig. 1A) composed of 6 abdominal somites, last somite continuous with telson. Abdominal somite 3 slightly dorsal hump-back. Abdominal somite 4 with dorsomedian tuft of setae. No abdominal somite with posterolateral spine. Pleopods absent.

Telson (Fig. 1C) triangular with deep posterior indentation. Posterior margin with 7+7 setae. Row of minute spinules present along base of setae 2-13. Anus opening ventrally near apex of telson. Uropods absent.

Antennule (Fig. 1D). Peduncle unsegmented. Inner flagellum with long plumose seta. Outer flagellum with 4 aesthetascs and short plumose seta.

Antenna (Fig. 1E). Peduncle with basal spine. Endopod with 2 rows of denticles and fine hairs on inner and outer margins. Scale 4-segmented at distal end with 10 plumose setae and distolateral spine.

Mandibles (Fig. 1F) asymmetrical without palps. Incisor and molar processes well developed. Left mandible with *lacinia mobilis* between molar and incisor processes. Right one with tooth at corresponding site.

Maxillule (Fig. 2A). Coxal endite with 6 plumodenticulate setae. Basial endite with 5 stout plumodenticulate setae. Endopod 2-segmented with 2 and 3 plumodenticulate setae.

Maxilla (Fig. 2B). Coxal endite bilobed with 8 and 4 plumodenticulate setae. Basial endite bilobed with 4 and 3 plumodenticulate setae. Endopod 3-lobed with 3, 2, 4 plumodenticulate setae. Scaphognathite with 5 marginal plumose setae.

First maxilliped (Fig. 2C). Coxa with 6 plumodenticulate setae, arranged 1, 2, 1, 2. Basis with 12 plumodenticulate setae, arranged 3, 3, 3, 3. Endopod 4-segmented with 3, 1, 2, 3+1 plumodenticulate setae. Exopod with 1 subterminal and 3 terminal natatory setae.

Second maxilliped (Fig. 2D). Coxa with plumose seta. Basis with 9 plumodenticulate setae, arranged 1, 2, 3, 3. Endopod 4-segmented with 3, 1, 2, 4+1 plumodenticulate setae. Proximal segment of endopod with fringe of hairs on outer margin. Exopod with 2 subterminal and 3 terminal natatory setae.

Third maxilliped (Fig. 2E). Coxa unarmed. Basis with 3 plumodenticulate setae. Endopod 4-segmented with 2, 1, 2, 3+1 plumodenticulate setae. Exopod with 2 subterminal and 3 terminal natatory setae.

Pereiopods 1-2 rudimentary.

Chromatophores. Orange red chromatophores occurring on, antennule peduncle, anterior to eyestalks, carapace, coxa of first maxilliped, exopod of second maxilliped, endopod and exopod of third maxilliped, abdominal somite 5 ventrally, abdominal somites 1-3 and 6 laterally, and anteromedian region of telson dorsally. Yellow ones on abdominal somite 3 laterally.

DISCUSSION

A number of differences to the previous descriptions of *Heptacarpus rectirostris* by Yokoya (1957) and Yamashita and Hayashi (1979) from that of present study are observed (Table 2).

Table 2. Comparison of the morphological features of the first zoea of *Heptacarpus rectirostris* as given by Yokoya (1957) and Yamashita and Hayashi (1979) with those obtained in the present study. Maxp = maxilliped; * = data from figure; @ = from proximal to distal endites; + or – = presence or absence; ! = the number of distal segment

Larval characteristics		Yokoya (1957) as <i>Spirontocaris rectirostris</i>	Yamashita and Hayashi (1979)	Present study
Body length	length	1.9 mm	?	1.62 mm
Carapace	rostrum	≈ 0.63 mm	0.45–0.50 mm	0.39 mm
	dorsomedian papillae	minute, pointed	–	minute, pointed
	anteroventral denticle	–*	anterior, posterior	anterior, posterior
	pterygostomial spine	–*	2	2
Abdomen	somite 3	?	+ dorsal hump-back	+ dorsal hump-back
	somite 4	with short spine	without short spine	without short spine, with dorsal tuft of setae
Antennule	outer flagellum	3 aesthetascs*	?	4 aesthetascs, 1
Antenna	endopod	without denticles	with 2 rows of denticles*	with 2 rows of denticles
	scale (!)	10, 1 spine (incompletely 7)	11 (4–5)	10, 1 spine (4)
	basal spine	?	?	+
Maxillule	endopod	1, 3*	?	2, 3
	basal endite	4*	?	5
	coxal endite	4*	?	6
Maxilla	endopod	4*	?	3-lobed [3, 2, 4 (9)]
	scaphognathite	5	?	5
	basal endite@	?	?	4, 3
	coxal endite@	?	?	8, 4
Maxp I	exopod	4 (3 terminal, 1 subterminal)	3 (3 terminal*)	4 (3 terminal, 1 subterminal)
	endopod	3, 1, 2, 2*	?, ?, ?, ?	3, 1, 2, 3+1
	basis	8	?	3, 3, 3, 3 (12)
	coxa	2	?	1, 2, 1, 2 (6)
Maxp II	exopod	5 (3 terminal, 2 subterminal)	5 (3 terminal, 2 subterminal*)	5 (3 terminal, 2 subterminal)
	endopod	2, 1, 2, 1+1*	?, ?, ?, ?	3, 1, 2, 4+1
	basis	1, 1, 2, 2 (6)	?	1, 2, 3, 3 (9)
	coxa	–*	?	1
Maxp III	exopod	5 (3 terminal, 2 subterminal)	5 (3 terminal, 2 subterminal*)	5 (3 terminal, 2 subterminal)
	endopod	1, 0, 0, 1, 3+1	?, ?, ?, ?, ?	2, 1, 2, 3+1
	basis	1	?	3
Pereiopods		rudimentary	pereiopods 1–2	pereiopods 1–2

Yokoya (1957) described that the first zoea of *H. rectirostris* had the abdominal somite 4 with short posterolateral spine. Moreover, Yamashita and Hayashi (1979) described the first zoea of *H. rectirostris* without the rostrum. However, our observations reveal the first zoea of *H. rectirostris* without short posterolateral spine on the abdominal somite 4 and with the rostrum. The former difference probably was resulted of the artifact from microscopic observation or misidentification of adult shrimp because the presence of short posterolateral spine on the abdominal somite 4 is not a characteristic of the first zoea of *H. rectirostris*. The later one could be probably explained by the difficulty of observing the rostrum in the first zoea because it is too minute.

Based on the larval descriptions of four species *H. camtschaticus*, *H. brevirostris*, *H. paludicola*, and *H. tridens*, Haynes (1985) summarized the larval characters of *Heptacarpus*. His definition, however, is somewhat erroneous because the larval characteristics of the first zoea of *H. futilirostris* do not fit into his definition. Haynes (1985), for instance, reported that the larval characters of *Heptacarpus* are the abdominal somites without the posterolateral spine in the first stage and the pereopods 1-2 with the exopod in later stages. However, the larval description of *H. futilirostris* provided by Yang (1999) shows the abdominal somites 4-5 with the posterolateral spine and the pereopods 1-4 with the exopod in later stages. Within *Heptacarpus*, it is likely to appear that the exopod of pereopods in later stages is present on either the pereopods 1-3 (in *H. geniculatus* and *H. pandaloides*) or the pereopods 1-4 (in *H. futilirostris* and *H. rectirostris*) (cf. Kurata, 1968b, c; Yamashita and Hayashi, 1979, 1980; Yang, 1999). Moreover, Haynes (1985) noted that the tip of the exopod of the antenna of *Heptacarpus* is not always segmented in the first stage. However, the segmentation of the tip of the exopod of the antenna of *Heptacarpus* is homogeneous and always segmented in the known first zoeas of *H. futilirostris*, *H. rectirostris*, *H. camtschaticus*, *H. geniculatus*, and *H. pandaloides* (Yamashita and Hayashi, 1979, 1980; Haynes, 1981; Yang, 1999).

From the available descriptions of the larvae of *Heptacarpus*, the larval characters of the first zoeas of *Heptacarpus* can be summarized as follows: rostrum minute; carapace with anterior and posterior dorsomedian papillae, without midventral and posteroventral denticles; all abdominal somites without posterodorsal spine, abdominal somite 4 with dorsomedian tuft of setae; telson triangular with deep posterior indentation, with 7+7 posterior setae; inner flagellum of antennule with long plumose seta; endopod of antenna with 2 rows of denticles on distal half, exopod always segmented distally; maxillule without outer seta, endopod 2-segmented: proximal and distal segments with 2 and 3 setae, respectively; endopod of maxilla 3-lobed with 3, 2, 4 (9) setae, basal and coxal endites 2-lobed each; endopod of first maxilliped 4-segmented with 3 (rarely 4), 1, 2, 3 terminal+1 subterminal setae, exopod with 3 terminal natatory setae; basis of second maxilliped with 9 setae, arranged 1, 2, 3, 3, endopod 4-segmented with 3, 1, 2, 4 terminal+1 subterminal setae, exopod with 3 terminal natatory setae; endopod of third maxilliped 4 or 5-segmented: proximal segment with 2 setae, penultimate with 2, and ultimate with 3 terminal+1 subterminal setae, exopod with 3 terminal natatory setae. The first zoea of *H. camtschaticus* described by Haynes (1981) had the inner flagellum of antennule with plumose seta and spine, and the outer flagellum of antennule with three subterminal and four terminal aesthetascs. These could not be adopted as the larval characters of *Heptacarpus*, because the other species of *H. futilirostris*, *H. pandaloides*, *H. geniculatus*, and *H. rectirostris* have long plumose seta on the inner flagellum of

antennule and four (rarely three in *H. pandaloides*) terminal aesthetascs only on the outer flagellum of antennule.

Larval studies were done for the five species of *Heptacarpus* from Korea and adjacent waters: *H. camtschaticus*, *H. futuhirostris*, *H. geniculatus*, *H. pandaloides*, and *H. rectirostris*. The first zoea of *H. rectirostris* is more closely related to that of *H. futuhirostris* than to *H. camtschaticus*, *H. geniculatus*, and *H. pandaloides* by having the carapace with two anteroventral denticles behind the pterygostomial spine. *H. rectirostris*, however, is readily distinguished from *H. futuhirostris* by the absence of the posterolateral spine on the abdominal somites 4-5. Other distinguishing characteristics between the two species are included to the following provisional key to the first zoeas of *Heptacarpus* known from Korea and adjacent waters.

Key to the first zoeas of *Heptacarpus* known from Korea and adjacent waters

1. Exopod of antenna 4 or 5-segmented distally; pterygostomial spine present; carapace with 2 anteroventral denticles 2
 - Exopod of antenna 4-segmented distally; pterygostomial spine absent; carapace without anteroventral denticles 3
2. Exopod of antenna 5-segmented distally; abdominal somites 4-5 with posterolateral spines; coxal endite of maxillule with 7 setae *H. futuhirostris*
 - Exopod of antenna 4-segmented distally; abdominal somites 4-5 without posterolateral spines; coxal endite of maxillule with 6 setae *H. rectirostris*
3. Endopod of antenna at least 80% the length of exopod 4
 - Endopod of antenna 66% the length of exopod *H. geniculatus*
4. Exopod of antenna with 11 plumose marginal setae *H. camtschaticus*
 - Exopod of antenna with 9 plumose marginal setae *H. pandaloides*

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제1조애아 유생과 좁은빨꼬마새우속의 유생형질

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요 약

좁은빨꼬마새우의 제1조애아 유생기를 상세히 재기재·도시하였다. 좁은빨꼬마새우의 제1조애아 유생은 갑각에 두개의 앞배작은가시와 앞옆모가시를 가져 북방좁은빨꼬마새우, 긴좁은빨꼬마새우 및 *H. geniculatus*보다 절좁은빨꼬마새우와 상당히 가깝지만 제4-5배마디에 뒤옆가시를 가지지 않아 절좁은빨꼬마새우의 제1조애아 유생과 분명하게 구별되었다. 한국근해에 보고된 꼬마새우과 종의 유생기재목록과 좁은빨꼬마새우속 종에 대한 제1조애아 유생검색표가 제시되었다.